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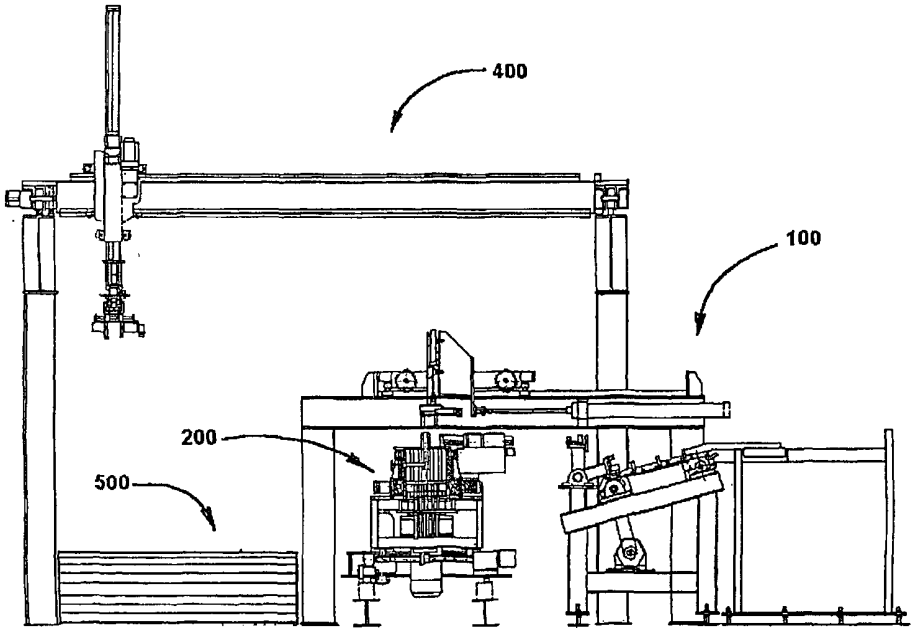
(54) Title: AUTOMATED BAR BENDER



(57) Abstract: An automated bar bending system with a bar bending unit for bending bars to a predetermined angle, an in-feeding system for receiving pre-cut bars for transferring one or more bars to the bar bending system, and an unloading system for unloading shaped bars from the bar bending system to a prescribed position at a prescribed location. The bending unit contains a former assembly, a drive pin assembly and a backup clamp assembly. The bar bending unit may be provided to a machine controller and actuating mechanisms such that different size bars may be automatically shaped to a prescribed angle according to user specification. In the preferred embodiment, the former assembly includes a series of concentric former rings mounted within a former housing. Each of the rings is provided with an actuating mechanism for moving it between a standby position and a forming position.

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AUTOMATED BAR BENDER

FIELD OF THE INVENTION

The present invention relates to bending apparatus for shaping bars. In particular, the present invention relates to automated bar benders.

BACKGROUND OF THE INVENTION

Machines for bending bars, particularly metal bars are known in the art. US Patent no. 4,555,924 discloses a bending machine that includes a feed device that is advanced with a stepped feeding movement. A continuous metal wire from a spool is driven past a straightening device made of a number of rollers, and the bending device then bends one bar at one time. US Patent 5,182,932 describes a bar bending apparatus having at least one pair of operation-controlled gripper tongs which can be swivelled from a first position, in which they receive a plurality of bars from the bar feed device and clamp the bars, into a second position, in which they insert the bars into the gap between the bending members. These machines however, are generally not fully automated. Others can handle only small numbers of bars. There is therefore a need for an improved bar benders.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides, in one aspect, an automated bar bending system with a bar bending unit for bending bars to a predetermined angle, an in-feeding system for receiving pre-cut bars for transferring one or more bars to the bar bending system, and an unloading system for unloading shaped bars from the bar bending system to a prescribed position at a prescribed location. The bending (also referred to as shaping), transferring and unloading functions are preferably performed concurrently for maximum efficiency.

In another aspect, an automated bar bending unit is provided. The unit contains a former assembly, a drive pin assembly and a backup clamp assembly. The automated bar bending unit is provided with a machine controller and actuating mechanisms such that different size bars may be automatically shaped to a prescribed angle according to user specification.

In the preferred embodiment, the former assembly includes a series of concentric former rings mounted within a former housing. Each of the rings is provided with an actuating mechanism for moving it between a standby position and a forming position. A machine controller is provided for controlling the actuating mechanism and to divide the rings into a first group and a second group, with each group containing zero or more rings. During operation, the first group of rings are actuated into the forming position, while the second group is

retracted into a standby position. As a result, the diameter and the bending curvature of the bar can be adjusted according to the user's specification.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of one embodiment of the present invention. Showing the in-feed system, bending system and unloading system

Figure 2 is a side view (view A as indicated in Fig.1) of the same embodiment of the present invention. Some details are omitted intentionally for clarity of the illustration.

Figure 3A and 3B are side and perspective views respectively of the in-feed system showing the storage and loading section, the buffer and conveying section and the transfer section.

Figure 3C is a closed up view on the left side of Figure 3B.

Figure 4A is a perspective view of the bending system showing the two bending units, the intermediate support and X-axis rails.

Figure 4B is a perspective view of one of the bending units.

Figure 4C is the close up view on part of a bending unit showing the drive pin, former and backup clamp.

Figure 4D is the front view of the bending unit. Some details are omitted intentionally for clarity of the illustration.

Figure 4E is a cross-sectional view of the same bending unit.

Figure 4F is a perspective view of the bending unit showing the alternative preferred embodiment of the backup clamp assembly.

Figure 5A is the perspective view of unloading system showing the three unloading gripper assembly and support structure.

Figure 5B is a closed up perspective view of one of the unloading gripper assembly.

Figure 5C is a closed up view of the Figure 5B unloading gripper showing the Z-axis structure, Y-axis structure and gripper assembly.

Figure 5D is a closed up view of the Figure 5B unloading gripper showing the X-axis assembly.

DESCRIPTION OF THE INVENTION

The automated bar bending and sorting machine **10** according to the preferred embodiment of the present invention is shown in Figures 1 and 2 comprising 4 sub-systems, a bar bending system **200** comprises two bar bending units **210** for bending the pre-cut bars, an elongated in-feed system **100** for receiving and aligning pre-cut bars, and also to deliver the bars to the bending system **200**, an unloading system **400** for transferring the shaped bars away from the bending system **200**, and a conveying system **500** for storage and transporting the shaped bars away from the entire system **10**.

Referring also to Figures 3A-C, the in-feed system **100** includes an elongated storage table **110** for receiving pre-cut bars, and an elongated and downward sloping buffer conveyor **120** aligned against one long side of the storage table **110**. A Turning device **130** is connected to the bottom of the buffer conveyor **120** and adapted to receive bars that are transferred from the buffer conveyor **120**. A transfer mechanism **140** is provided above the buffer conveyor **120** for transferring the bars from the turning device **130** to the bending units **210**.

The storage table **110** includes a bar storing area **111** and an adjacent rolling area **112**. Extending upwards and along one end of the rolling area is an alignment plate **113**. The buffer conveyor **120** contains a series of chain conveyors **121** driven by a common shaft

122 coupled to conveyor motor 123. The chain conveyors 121 move in the downward sloping direction perpendicular to the long edge 112a of the rolling area 112. On each chain are attached stopper fingers 124 extending outwardly at equal intervals. The space between two stopper fingers 124 define a buffer slot 125 and the distance between two fingers is the index spacing 126.

The transfer mechanism 140 includes a row of transfer grippers 141 mounted on a transfer bar 142 that is aligned parallel to the long edge 112a of rolling area 112. Transfer bar 142 is in turn slidably mounted on a set of transfer rails 143 that are provided perpendicular to the long edge 112a of the rolling area. Each transfer gripper 141 contains a vertically aligned transfer arm 144 that is attached at the base to a pair of transfer jaws 145. Pneumatic actuators 146 and 147 are provided to allow transfer arm 144 to move in the Y- and Z-directions respectively. Actuator 148 is provided to allow transfer jaws 145 to open or close.

The turning device 130 includes a row of turning grippers 131 mounted on a rotatable shaft 132 that is positioned parallel to the edge 112a of the rolling area, and between the transfer mechanism 140 and the buffer conveyor120. The turning grippers 131 overlap and interpolate between the chain conveyors 121. Actuators 133 are provided to rotating the turning grippers 131 between an inclined receiving position131' and a vertical transfer position131". The inclination of the turning gripper 131 in receiving position

131'correspond to the inclination of the buffer conveyor **120** and is aligned with the lowest buffer slot of the buffer conveyor **120**. Each turning gripper **131**includes a pair of turning jaws **134** that can be actuated to open or close.

The bending system **200** is provided within and below the transfer mechanism **140** and the unloading system **400**. Referring to the embodiment shown in Figure 4A-4D, the bending system consists of 2 bending units **210** , 1 pair of bending rails **330** and a series of intermediate supports **350**. The 2 bending units **210** are essentially mirror image of each other.

Each bending unit **210** contains a bending head **220** and a positioning structure **310**. The positioning structure **310** is to position the bender head **220** in X-direction (a direction parallel to the long edge **112a** of rolling area **112**) and Y-direction(a direction perpendicular to the long edge **112a** of rolling area**112**).

The positioning structure **310** containing roller wheels **311** and drive unit **312** and enable the bending units **210** to slide independently along bender rails **330** for movement along X-axis. The roller wheels **311** are installed in such a way that some of them rotate about the vertical (Z) axis and some about the horizontal (Y) axis so as to support the load of the bending unit **210** and to restrain lateral (Y-axis) movement. The drive unit **312** moves and positions the bending units

210 along the bender rail 330. Drive unit 312 includes a positioning gear motor 313mounted on positioning structure base plate 314. Pinion gear 315 is installed on the gear motor 313 and match with the racks 316 that are mounted on bending rails 330. As the drive unit 312 is actuated, the pinion gear 315 runs on rack 316 and moves the bending unit 210 along the X-co-ordinate and may be position in any pre-determined position.

The positioning structure 310 also containing guide shafts 321 and a second drive unit 322. The bending head 220 is slidably mounted on the guide shafts 321 with guide bushes 327. Guide bushes 327 support the load of the bending head 220 and restrain lateral movement in the X-axis. The drive unit 322 moves and positions the bending head 220 along the guide shafts 321. Drive unit 322 includes a positioning gear motor 323, lead screw shaft 324 and lead screw nut 325Lead crew shaft 324 is coupled to the gear motor 323. the lead screw nuthousing fix the lead screw nut 325 on the base of the bending head 220. As the drive unit 322 is actuated, the lead screw shaft 324 rotates and move the lead screw nut 325 together with the bending head 220 along the Y-direction and may be positioned in any pre-determined position.

Along the length of rails 330 , intermediate supports 350 are provided at predetermined positioned between the two bending units

210. Intermediate support 350includes a clamp assembly 351, a retractable structure 352 and a fixed structure 353. The clamp assembly 351 contains a clamp 354 and an actuator 355. One jaw of clamp 354 is fixed and the other jaw is movable by actuator 355 to open or close the clamp 354. Under operating conditions, clamp 354 is along the same reference Y-co-ordinates as the clamp jaw 273 of the backup clamp assembly 270. Retractable structure 352, when extended, positions the clamp 354 at the reference Y-co-ordinates; when it is retracted, the entire retractable structure 352 and clamp assembly 351 is moved out of the X-axis path of the bending units 210.

The bending head 220 includes the former assembly 230, the drive pin assembly 250, backup clamp assembly 270 and motor gear drive assembly 290.

The former assembly 230 includes a former housing 231 and a series of concentric cylindrical former ring 232. The former housing 231 is secured to the bending head table top 233. The former ring 232 are housed within former housing 231. Each former ring 232 have a key slot 234 at the low portion and is connected to a former actuator 235 at the bottom. When former actuator 235is actuated, it raises the top portion of the former ring 232 above the bending head table top 233. During retraction, the former actuator 235 retracts the entire former ring 232 such that it is flush with the table top 233. The key slots 234 of all former

rings 232 are aligned together and this alignment is maintained with a common key 236 inserted from the side of former housing 231. The common key 236 prevents the rotation of the former ring 232 with respect to the former housing 231. The key slot 234 is elongated such that it is not impeding the extension and retraction of the former ring 232.

The drive pin assembly 250 includes a drive pin 251, a drive shaft 252, a shaft housing 253 and a support housing 254. The entire drive pin assembly 250 is installed on and rotates with the bending gear 293 about the centre of the former ring 232. The support housing 254 are secured on the bending gear 293. The shaft housing 253 is slidably housed in the support housing 254. Actuator 255 is mounted on the support housing 254 and, when actuated, raises the shaft housing 253 such that the bottom edge of the drive pin 251 is above the table top 233 and when retracted, lowered the shaft housing 253 such that the entire drive pin assembly 250 is below the table top 233. Keys 256 are provided on the contact surfaces of the support housing 254 and shaft housing 253 for guiding shaft housing 253 vertical movement and to withstand the load generated during bending.

The drive shaft 252 is slidably housed in the shaft housing 253 and can slide toward or away from the centre of the bending head 220 (i.e. centre of the former assembly 230). The slide movement is guided

by key **261** installed between the contact surface of the shaft housing **253** and drive shaft **252**. A drive unit **257** consists of positioning gear motor **258** and lead screw are secured to the shaft housing **253**. When the drive unit **257** is actuated, the lead screw rotates and advance or retract a lead screw nut fitted on it. As the lead screw nut is secured on the drive shaft **252**, the drive shaft **252** will move forward or aft accordingly.

The backup clamp assembly **270** is provided on one side of the bending head table top **233** and includes a clamp unit **271** and a clamp adjustment unit **272**. The clamp unit **271** is slidably mounted on the clamp adjustment unit **272** and includes a pair of clamp jaws **273** and a hydraulic clamp jaw actuator **274** which open or close the clamp jaws **273**. The adjustment unit **272** is mounted to the table top **233**. It has drive unit **275** includes a positioning gear motor **276**, lead screw **277**and lead screw nut **279**. As the drive unit **275** is actuated, the lead screw **277** turn and move the clamp unit **271** toward or away from the centre of bending head **220**.

Before bending, the relative lateral position of the drive pin **251**, raised former ring **232** and backup clamp unit **271** have to be adjusted according to the diameter of the bar for which bending or forming is desired, former ring diameter and direction of bending i.e. forward or reverse bending(will be discussed in further detail later). This

adjustment is required such that the bars to be shaped can be placed in the gap **278** provided between drive pin **251** and raised former ring **232** and clamped by the clamp unit **271** substantially parallel to the X-direction.

In this preferred embodiment, the positioning structure **310** moves the bending head **220** in Y-direction, the backup clamp assembly **270** (and hence the clamp unit **271**) move together with it. The clamp adjustment unit **272** moves the clamp unit **271** in the reverse Y-direction by the same amount and in synchornisation with the y-direction movement such that there is no change in the absolutes clamp unit **271** Y-co-ordinates before, during and after the move. This is advantageous in this invention as a common lateral (Y-co-ordinates) position regardless of bar size or former size or during reverse bending simplified bending, feeding and unloading system design and operation.

Another preferred embodiment of the backup clamp assembly **280** comprises a clamp unit **281** and a support structure **282**. The clamp unit **281** includes a pair of clamp jaws **283** and a hydraulic clamp jaw actuator **284** which open or close the clamp jaws **283**. The clamp unit **281** is mounted on support structure **282** which in turn is mounted on the base plate **285** of the positioning structure.

The motor gear drive assembly **290** includes a driving gear motor **291** driving gear **292**, bending gear **293** and bearing assembly **294**. The driving gear motor **291** is coupled together with the driving gear **292** The bending gear **293** is engaged with and driven by the driving gear **292**. The bending gear **293** is mounted on the rotatable bearing housing **295** of the bearing assembly **294**. Bearings **296** are placed in between the rotatable bearing housing **295** and the fixed former housing **231**. As the driving gear motor **291** rotates, the drive pin assembly **250** mounted on the bending gear **293** will be rotated in either forward or reverse direction. The rotation angle of drive pin **251** about the former ring **232** and hence the bending angle of the bar is controlled by the driving gear motor **291** turning angle. Various limit switches are mounted on the bending unit to prevent over-travel of drive pin in the forward and reverse direction.

Referring now to Figures 5A-5D, the unloading system **400** contains 2 carriage rail **410** supported on 4 floor mounted columns **411**. Three essentially identical unloading carriages **420** are slidably mounted on the carriage rails **410**. Each unloading carriage **420** comprises a horizontal guide beam **430**, carriage roller assembly **440**, a guide assembly **450**, a vertical pickup bar **460** and a unload gripper **470** attached on the lower end of the pickup bar **460**.

The two ends of the horizontal guide beam **430** are fastened to the 2 carriage roller assembly **440**. Each carriage roller assembly **440** has 2 support rollers **441** to support the weight of the unloading carriage **420** and 2 guide roller **442** to restraint the lateral movement (Y-axis movement) of horizontal guide beam **430**. A carriage motor **443** drive the unloading carriage **420** to travel on the carriage rails **410** by mean of rack **444** and pinion **445**.

The guide assembly **450** comprises a beam guide **451** and a bar guide **452**. The beam guide **451** is slidably mounted on the horizontal guide beam **430** with a series of guide and support rollers **453**. It have a drive motor **454** to drive the guide assembly **450** along the horizontal guide beam **430**. The bar guide **452** has a series of guide rollers **455** and allows the vertical pick up bar **460** to be slidably mounted on it. The bar guide **452** has a drive motor **456** mounted on it to drive the pick up bar **460** up and down in the vertical direction.

The unloading gripper assembly **470** comprises a rotational assembly **471** and a gripper **472**.

The rotational assembly **471** comprises a rotational motor **473** and a spring loaded self-adjustment mechanism **474**. The rotational motor**473** can rotates the gripper **472** about the Z-axis to any predetermined angle and the self-adjustment mechanism **474** allows the gripper **472** to adapt to the final bar shape during the gripping action.

The gripper **472** comprises a pair of actuator driven gripper jaws **475** mounted on spring loaded guide rods **476**. Gripper jaw **475** open or close depending on the action of the actuator **477**. Spring loaded guide rod **476** allows the gripper jaw **475** to self-adjust to accommodate any error in the actuator direction. Depending on the shape of the bar and based on an intelligent picking logic, the three gripper **472** will automatically positioned itself to optimum pick up positions such that the shaped bar can be unloaded in a balanced and stable manner.

The conveyor system **500** is positioned under the unloading system **400**. It comprises a slat conveyor belt **510** driven by a conveyor gear motor (not shown). Conveyor system **500** simplify and speed up unloading system **400** operation. Before bending commences, unloading carriage **420** positions itself along carriage rail **410** according to the final bar shape. With conveyor system **500**, the unloading carriage **420** do not need to move in X-direction along the carriage rail **410** during unloading. The unloading gripper assembly **470** will move in Y and Z direction to pick up the shaped bar from the bar bending system **200** and place it on the conveyor system **500**. After the unloading gripper assembly **470** unload all the bars at the first location on the conveyor system **500**, the conveyor gear motor moves the slat conveyor belt **510** to bring an empty space on the slat conveyor belt **510** to the next unloading position. A computerised nesting program is incorporated in the machine controller to optimise the conveyor system **500** storage

capacity. When the conveyor system **500** is full and no location are available for unloading, all bars on the conveyor system **500** are conveyed away to a conventional bundling station for bundling. The empty conveyor system **500** will then be ready for the unloading system **400** again.

During operation. An operator receives pre-cut or cut-to–length bars in bundles and places them on storage area **111**. In this area, the bundles are cut open and the bars to be shaped are segregated and transferred to the rolling area **112**.

Before loading these bars into the buffer conveyor **120**, bar information such as shape and size of these bar are either download from a network system or input by operator keying in or scanning in bar code into the machine controller. Base on these information, the machine controller initiate the system to perform a set up operation. This set up operation involve setting up the in-feed system **100**, the bending system **200**, the unloading system **400** and the conveyor system **500** such that they are ready for bending operation. During set up operation, the bending heads **220** position themselves in the X and Y positions, the drive shaft **252** moves above the table top **233** and extend forward to a position predetermined by the machine controller. The predetermined number of former rings **232** will be pushed up and have their top half emerge above the table top **233**. The backup clamp

assembly **270** is aligned with the gap **278** in the reference position Predetermined number of intermediate supports **350** will be extended to the ready position. Those transfer grippers **141** that will be in used in the bending operation will be activated and those transfer grippers **141** not in use will be deactivated. The 3 unloading gripper assemblies **470** position themselves in X, Y , Z and G direction. The conveyor system **500** moves the slat conveyor belt **510** such that an optimum empty space on the conveyer system **500** is ready for the unloading system **400** to unload the shaped bars.

Once the set-up operation is completed, bending operation can commence. The operator at the rolling area **112** aligns the bar end with the alignment plate **113** before a prescribed number of bars are laterally fed into the buffer conveyor **120**.

Rolling area **112** contains a series of rollers to facilitate alignment of the bars to the alignment plate **113** and a declination angle at the side next to the buffer conveyor **120** to facilitate the rolling of bars form the rolling area **112** down to the buffer slot **125**. The prescribed number of bars is thus laterally aligned in one row on the buffer conveyor **120**. The set of bars is the buffer slot **125** from a downward sloping array. The operator then indexes the buffer conveyor **120** forward by one slot in the Y-direction. The next slot is then loaded by the operator repeating the aligning and rolling action to load the next set of bars into the next buffer slot **125**. The buffer conveyor **120** can also be multiple

indexed for fast-forwarding towards the turning device **130**. The turning device **130** is set to the receiving position **131'** such that the turning gripper **131** are aligned with the lowest buffer slot **125**. As the first set of bars is forwarded downwards from the buffer conveyor **120**, the bars are inserted laterally into the turning gripper **131**, which then grips and rotates the array of bars to the transfer position **131"**. In the transfer position **131"**, the individual bar remains in a horizontal position, but if more than one bar is presented, the additional bars are stacked one directly above another in a vertical array due to the turning action of the turning gripper **131**. The transfer grippers **141**, which interpolate between the turning grippers **131** have pre-set combination of "in", "out", "up" and "down" positions. In the "in-down" position, the transfer grippers **141** are moved downwards to align with the vertical array of horizontal bars held up by the turning gripper **131**. After gripping the array of bars, the turning grippers **131** release their grip, and the transfer grippers **141** then move the bars upwards in the Z-direction, followed by movement in the Y-direction towards the bending units **210**. In the "out-down" position, the transfer grippers **141** are aligned (same Y-co-ordinate) with gap **278** of the bending unit **210**. Once the array of bars is properly positioned within gap **278**, the clamp unit **271** close to grip the bars, the transfer grippers **141** open to release the bars and move back to the "in-down" position to retrieve the next set of bars. The clamp jaws **273** of backup clamp assembly **270** are also aligned to the gap **278**

such that the array of bars is lowered into the clamp jaws **273** when the transfer grippers **141** move to the "out-down" position. The clamp **354** of the intermediate support **350** is also aligned to the same Y-co-ordinate as gap **278** such that the array of bars are lowered into clamp **354** in the same "out-down" position, and the bars are supported during the bending process. Meanwhile, the turning grippers **131** move back to the receiving position **131'** to receive and turn the next set of bars. Bending is achieved by the turning movement of the drive shaft **252** that is driven by the rotating movement of the bending gears **293**.

In this preferred embodiment, it is found to be advantages to have the bar fed onto the bending unit **210** at a fixed reference Y-Co-ordinates regardless of bar size and former rings **232** used. The infeed system **100** described above has transfer grippers **141** to load the bars onto bending unit **210** at this reference Y-co-ordinate.

The bending unit **210** in the preferred embodiment is an automated apparatus that can be easily adjusted to receive bar form the infeed system **100** and bend or shape bars of different diameters and to different degrees of curvature.

To achieve this, the bending unit adjust the gap **278** provided between the drive pin **251** and the former rings **232** , the clamp jaw **273** of backup clamp assembly **270**, and the clamp **354** of the intermediate support **350** to be aligned with the reference Y-co-ordinate. These adjustments arise due to the different former ring **232** being used. As

different former rings **232** are used, the gap **278** change its Y co-ordinate. To compensate for the co-ordinate change, the bending units **210** moves in the Y-direction such that the gap **278** resume its reference Y-coordinates. As the bending units **210** move in Y-direction, the backup clamp assembly **270** mounted on it moves with it and away from the reference Y-co-ordinate. A clamp adjustment unit **271** is provided to move the clamp unit **271** in the opposite direction by the same amount such that the clamp unit **271** is back to the original reference Y-co-ordinate.

To made the system easily adjustable for bending or shaping different diameters of bars and achieving different degrees of curvature, the bending unit **210** is provided with a series of concentric former rings **232** having former actuators **235** that allow them to be automatically raised or retracted below the bending unit table top **233**. During operation, the former ring **232'** with the prescribed diameter will be raised for bending. For better strength, all other former rings smaller than the prescribed former ring **232'** are preferably raised during forming. In the preferred embodiment, a single anti-rotation common key **236** is provided to prevent the former rings **232** form rotation during bending. To ensure that former rings **232** can slide easily over each other even after a long period of operation, former rings **232** are preferably made of hardened material to minimise wear, and the portion of the former rings **232** surface in contact with the bars is slightly

recessed so that even if there are some deformation or metal flare, the sliding movement is not hampered. The drive pin assembly **250** has a drive pin **251** at the front. Its movement towards and away from the centre of the bending head **220** is controlled by the positioning gear motor **258**. The position of the drive pin **251** is dependent on the diameter of the prescribed former ring **232'** cylinders as well as the bar diameter. Once positioned, the prescribed former ring **232'** and drive pin **251** define a predetermined gap **278** between them where the bar is to be loaded. Other than turning in either direction for bending the bars forwards and backwards, the drive pin **251** can also be retracted below the table top **233** by actuator **255**.

For reverse bending while the bar or set of bars are still in the bending table top **233**, all former ring **232** are retracted below the table top **233** and move over to the opposite side of the bar by moving the bending head **220.** As bending head **220** are being move, the clamp adjustment unit **272** move the clamp unit **271** in the reverse direction such that the clamp unit **271** position is at all time at Y-reference co-ordinate. The drive pin **251** also fully retracted below the table top **233** by the combine action of positioning gear motor **258** and actuator **255**. The entire drive pin assembly **250** is than rotated to the opposite side of the bar by the motor gear drive assembly **290**. Once over at the opposite side of the bar, former rings **232'** will be raised and drive pin **251** will

also be raised and move toward the centre of bending head **220** to the prescribed position.

For bending of single-bend bars and many kinds of double-bend bars, there is no need for adjustment of bending unit **210** during bending once the initial set-up operation is completed. For single-bend bar, one bending unit performs the bending. For double-bend bar, each bending unit **210** performs one bend. However, for bars that have 3 or more bends, or double-bend bars that require bending to be performed by the same bending unit due to dimensional constraints, adjustment of co-ordinates of bending unit may be required. During the adjustment, clamp unit **271** of the moving bending unit will open and all intermediate support **350** in the way of the bending unit movement will be retracted away.

When all the bending or shaping on a bar or a set of bars have been performed, the unloading gripper assembly **470** will move in the Y direction to the reference Y-co-ordinates. The unloading grippers assembly **470** is then move down in Z direction to the same position as the "out-down" position of infeed system transfer grippers **141** to grip the bars. The clamp unit **271** of backup clamp assembly **270** and clamp **354** of intermediate support then open and the unloading gripper assembly **470** moves the bar up in the Z direction and out in the Y-direction and places the bar down in the Z direction onto the conveyor system **500**. As more and more bars are unloaded, the unloaded bars

are stacked up to create a higher and higher stack. To ensure that the unloading gripper assembly **470** do not crash onto the stack of unloaded bars, detecting devices are installed on the unloading gripper assembly **470** such that the bars will be unloaded at a predetermined distance from the top most bars on the stack.

The unloading grippers assembly **470** are pre-positioned to a ready position for picking up bars during the initial set up operation. The pick up positions are predetermined by the machine controller and is calculated based on the shape and CG of the bar. During set-up operation, the machine controller determines the positions and rotating angles of gripper **472** on each unloading carriage **420**. After set up, grippers **471** only move in the Y and Z directions and do not move in the G and X-directions during unloading to simplify control and minimise unloading cycle time.

The conveyor system **500** act as an unloading storage area for shaped bars on which bars are unloaded and segregated. As the unloading system **500** positions itself only base on the bar information from the machine controller and do not alter its X position during unloading. The conveyor system **500** takes care of that by ensuring that the location on which the unloading system **400** is going to unload is on an empty space. The slat conveyor belt **510** move in X direction to ensure that all bars on it will not interfere with the next bar to be unloaded.

An integrated system comprising the infeed system **100**, bending system **200**, unloading system **400** and conveying system **500** give rise to great benefit in bar bending operation. The fully automatic set-up operation greatly reduce operator set up time, skill level and human error. The fully automatic bending, unloading and conveying system reduces human resource requirements to a single operator at the infeed system side to just unbundling, aligning and loading bar into the buffer conveyor **120**. The greatest benefit of the system is realised through the parallel processing of the infeed, bending and unloading operations as compared to sequential processing as conventionally practice in the art.

While the present invention has been described particularly with references to the aforementioned figures, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. In addition, it is clear that the method and apparatus of the present invention has utility in many applications where automatic bar bending is required. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described.

CLAIMS

1 1 An automated bar bending and sorting system comprising :

2 a bar bending system for bending bars to a predetermined
3 angle;

4 an in-feeding system for receiving pre-cut bars, said in-feeding
5 system containing a transfer system for transferring one or more
6 bars to said bar bending system; and

7 an unloading system for unloading shaped bars from said bar
8 bending system to a prescribed position at a prescribed
9 location.

1 2 A system according to claim 1 wherein said transfer system
2 comprises

3 a conveyor system having an inclined conveyor with stopping
4 elements mounted at predetermined intervals and defining slots
5 therebetween;

6 a transfer mechanism having a vertical array of transfer grippers
7 slidably mounted on transfer bars; and

8 a turning device provided with turning grippers, said turning
9 grippers rotatable between an inclined receiving position and a
10 vertical transfer position, said turning gripper in said receiving

position aligned with said conveyor for receiving one or more pre-cut bars; said turning grippers in said transfer position adapted to co-operate with said transfer gripper to transfer said one or more pre-cut bars to said bar bending system.

3 A system according to claim 1 further comprising a conveying system having said prescribed location for receiving shaped bars and transferring said shaped bars therefrom.

4 A system according to claim 1 wherein said transfer system further comprises

a conveyor system having an inclined conveyor with stopping elements mounted at predetermined intervals and defining slots therebetween;

a transfer mechanism having a vertical array of transfer grippers slidably mounted on transfer bars; and

a turning device provided with turning grippers, said turning grippers rotatable between an inclined receiving position and a vertical transfer position, said turning gripper in said receiving position aligned with said conveyor for receiving one or more pre-cut bars; said turning grippers in said transfer position adapted to co-operate with said transfer gripper to transfer said one or more pre-cut bars to said bar bending system; and

said in-feeding system further comprises a preparation area including:

a storage area for receiving and holding said pre-cut bars; and

a rolling area having two opposing sides between two ends, said rolling area further having an alignment plate mounted at one end thereon, one side of said rolling area linked to said storage area and the other side of said rolling area linked to the top of said inclined conveyor.

5 A system according to claim 1 wherein said unloading system comprises a plurality of unloading carriages slidably mounted on carriage rails, said unloading unit further comprising an unloading gripper for gripping and unloading bars from said bar bending system at a prescribed location;

at least one horizontal guide beam for moving said gripper in the X-direction;

at least one pickup bar to move said gripper in the Y-and Z-direction; and

a rotational assembly to rotate said gripper about the Z-axis.

6 A system according to claim 5 further comprising:

a first spring loaded device coupled to said rotational assembly to accommodate differences in lateral position between said unloading gripper and said shaped bars; and

a second spring loaded device coupled to said unloading gripper to accommodate differences in angle between said unloading gripper and said bar.

17 A system according to claim 1 wherein said bar bending system further comprises:

at least one bending unit for bending said pre-cut bars to a predetermined shape; and

a plurality of bending rails for supporting said bending unit such that said bending unit can move in the X-direction thereon.

18 A system according to claim 7 wherein said bar bending system further comprises at least one intermediate support mechanism to give additional support to said pre-cut bar during the bending process.

19 A bar bending unit comprising a former assembly, a drive pin assembly and a backup clamp assembly, said former assembly comprising

a series of concentric former rings mounted within a former housing, each said ring provided with an actuating mechanism for moving said ring between a standby position and a forming position;

a machine controller for controlling said actuating mechanism and to divided said rings are into a first group and a second

group, each said group containing zero or more rings, said first group of rings in said forming position co-operating with said drive pin assembly and said backup clamp assembly to shape bars placed thereon, said second group of rings in said standby position withdrawn from the bending process.

10 A bar forming assembly comprising a series of concentric former rings mounted within a former housing, each said former ring provided with an former actuator for moving said former ring between a standby position and a forming position; said assembly further comprising a machine controller for controlling said former actuator such that said former rings are divided into a first group and a second group, each said group containing zero or more former rings, said first second group selected to move into a standby position while said second group is selected into the bending position.

11 A method of bar bending using an automated bar bending unit comprising :

entering information into the machine controller for said unit, said information comprising the size of said bar and at least one prescribed angle of bending;

moving a first group of former rings into a forming position using said machine controller, said first group containing zero or more former rings;

moving a second group of former rings into a standby position using said machine controller, said second group containing zero or more former rings; and

bending said bar into said prescribed angle.

12 A method of bar bending using an integrated bending system comprising:

feeding said bar into said bending unit;

bending said bar into a predetermined shape; and

transferring said formed bar to a prescribed location;

said method characterised in that said feeding, bending and transferring steps are performed concurrently.

AMENDED CLAIMS

[received by the International Bureau on 17 September 2001 (17.09.01);
original claims 1-12 replaced by amended claims 1-12 (7 pages)]

1 An automated bar bending and sorting system comprising:

a bar bending system for bending bars to a predetermined angle;

an in-feeding system for receiving pre-cut bars, said in-feeding system comprising a transfer system for transferring one or more bars to said bar bending system;

and

an unloading system having a plurality of unloading carriages, slidably mounted on carriage rails, for unloading shaped bars from said bar bending system to a prescribed position at a prescribed location.

2 The automated bar bending and sorting system as claimed in Claim 1, wherein said transfer system comprises:

a conveyor system having an inclined conveyor with stopping elements mounted at predetermined intervals and defining slots therebetween;

a transfer mechanism having a vertical array of transfer grippers slidably mounted on transfer bars;

and

a turning device provided with turning grippers, said turning grippers rotatable between an inclined receiving position and a vertical transfer position, said turning gripper in said receiving position aligned with said inclined conveyor for receiving one or more pre-cut bars, said turning grippers in said transfer position being adapted to co-operate with said transfer gripper to transfer said one or more pre-cut bars to said bar bending system.

3 The automated bar bending and sorting system as claimed in Claim 2, wherein said in-feeding system comprises a preparation area having:

a storage area for receiving and holding said pre-cut bars;

and

a rolling area having two opposing sides between two ends, said rolling area further having an alignment plate mounted at one end thereon, one side of said rolling area linked to said storage area and the other side of said rolling area linked to the top of said inclined conveyor.

4 The automated bar bending and sorting system as claimed in Claim 1, and further comprising a conveying system having said prescribed location for receiving shaped bars and transferring said shaped bars therefrom.

5 The automated bar bending and sorting system as claimed in Claim 1, wherein each of said plurality of unloading carriages comprises:

an unloading gripper assembly for gripping and unloading bars from said bar bending system at a prescribed location;

at least one horizontal guide beam, coupled to said unloading gripper assembly, for moving said unloading gripper assembly in the X-direction;

at least one pickup bar, coupled to said unloading gripper assembly, for moving said unloading gripper assembly in the Y-and Z-direction;

and

a rotational assembly to rotate said unloading gripper assembly about the Z-axis.

6 The automated bar bending and sorting system as claimed in Claim 5, and further comprising:

a first spring loaded device coupled to said rotational assembly to accommodate differences in lateral position between said unloading gripper assembly and said shaped bars;

and

a second spring loaded device coupled to said unloading gripper assembly to accommodate differences in angle between said unloading gripper assembly and said shaped bars.

17 The automated bar bending and sorting system as claimed in Claim 1, wherein said bar bending system comprises:

at least one bending unit for bending said pre-cut bars to a predetermined shape;

and

a plurality of bending rails for supporting said bending unit such that said bending unit can move in the X-direction thereon.

18 The automated bar bending and sorting system as claimed in Claim 7, wherein said bar bending system further comprises at least one intermediate support mechanism to give additional support to said pre-cut bar during bending.

19 A bar bending unit comprising:

a drive pin assembly;

a backup clamp assembly;

and

a former assembly having:

a series of concentric former rings mounted within a former housing, each of said former rings being

provided with an actuating mechanism for moving between a standby position and a forming position;

and

a machine controller for controlling said actuating mechanism and to divide said rings into a first group and a second group, each of said first and second groups having zero or more rings, said first group of rings in said forming position co-operating with said drive pin assembly and said backup clamp assembly to shape bars placed thereon, said second group of rings in said standby position withdrawn from the bending process.

10 A bar forming assembly comprising a series of concentric former rings mounted within a former housing, each said former ring provided with an former actuator for moving said former ring between a standby position and a forming position; said assembly further comprising a machine controller for controlling said former actuator such that said former rings are divided into a first group and a second group, each said group containing zero or more former rings, said first second group selected to move into a standby position while said second group is selected into the bending position.

11 A method of bending steel bars using an automated bar bending unit comprising :

entering information into a machine controller for said automated bar bending unit, said information comprising the size of a bar and at least one prescribed angle of bending;

moving a first group of former rings into a forming position using said machine controller, said first group containing zero or more former rings;

moving a second group of former rings into a standby position using said machine controller, said second group containing zero or more former rings;

and

bending said bar into said at least one prescribed angle.

12 A method of bending steel bars using an automated bar bending and sorting system, said method comprising the steps of:

feeding a bar into said system;

bending said bar into a predetermined shape;

and

transferring, using an unloading carriage slidably mounted on carriage rails, said bar in said predetermined shape to a prescribed location.

said method characterised in that said feeding, bending and transferring steps are performed concurrently.

STATEMENT UNDER ARTICLE 19 (1)

1) Claims 1 to 8 have been amended to better define an automated bar bending and sorting system;

   Specifically, the following amendments are made to these claims:
   a. The preamble for Claims 2 to 8, as amended, are re-worded to define an automated bar bending and sorting system;
   b. Claim 1, as amended, better defines the unloading system.
   c. Claim 3, as amended, is based on old Claim 4 and now depends on Claim 2;
   d. Claim 4 is a re-numbering of old Claim 3; and
   e. Claim 5, as amended, is based on old Claim 5 and now further defines the unloading system of Claim 1.

2) Claim 9 has been amended to define a bar bending unit for an automated bar bending and sorting system;
   a. This amendment is made in response to the unity of invention remark made by the Examiner in the International Search Report dated 18th July 2001.

3) Claim 10 has been amended to define a bar forming assembly for an automated bar bending and sorting system;
   a. This amendment is made in response to the unity of invention remark made by the Examiner in the International Search Report dated 18th July 2001.

4) Claim 11 has been amended to provide for bending steel bars in the preamble. In addition, Claim 11, as amended, now has clearer antecedent support within the claim for the machine controller, the bar bending unit and the at least one prescribed angle;

   and

5) Claim 12 has been amended to provide for bending steel bars in the preamble. In addition, Claim 12, as amended, now has clearer antecedent support within the claim for the integrated bending system and the bar. Further, the transferring step is amended to describe an unloading carriage for this transferring step.

The above Claim amendments have not added new matter and are supported by the specification and drawings as filed.

****

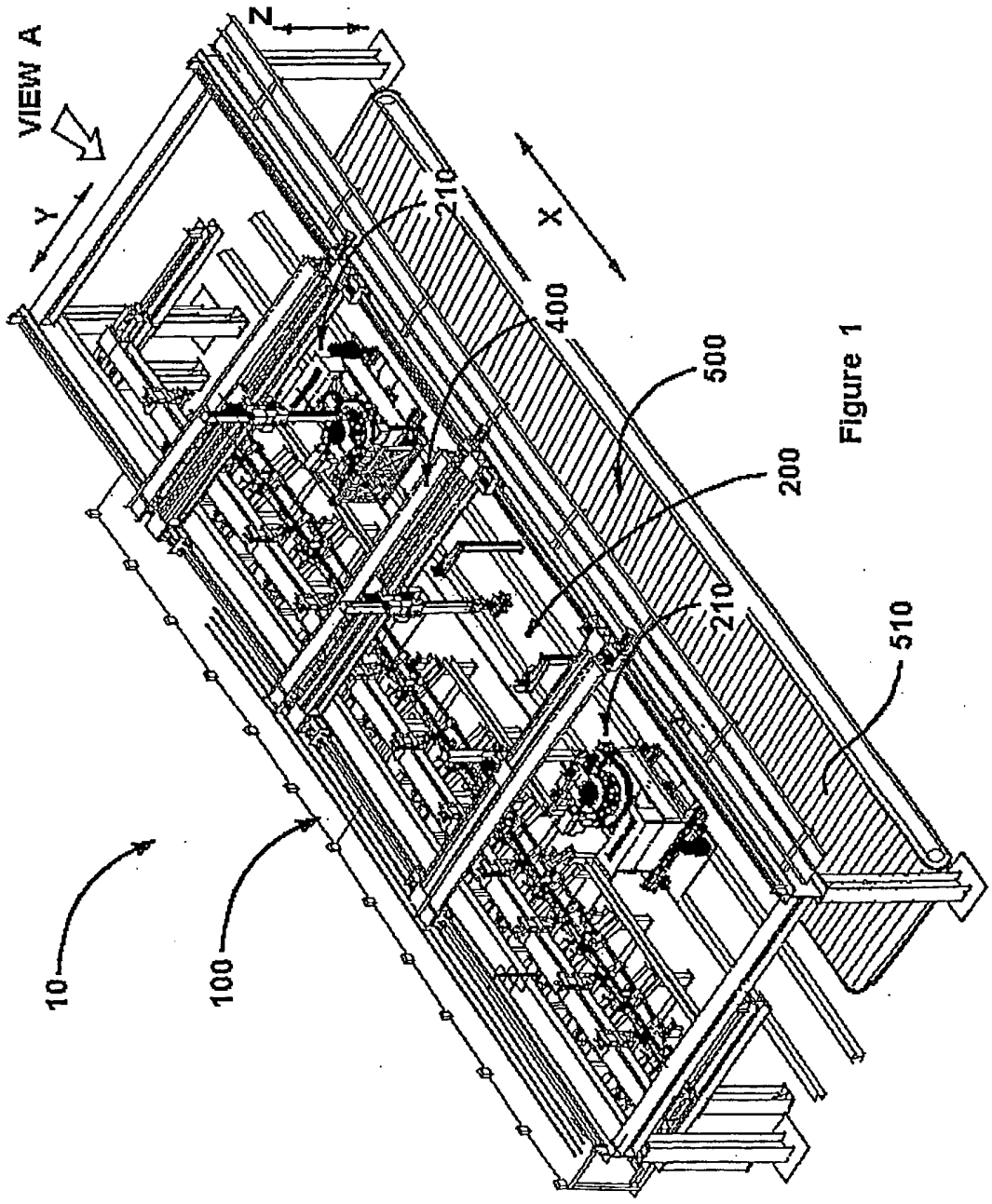

Figure 1

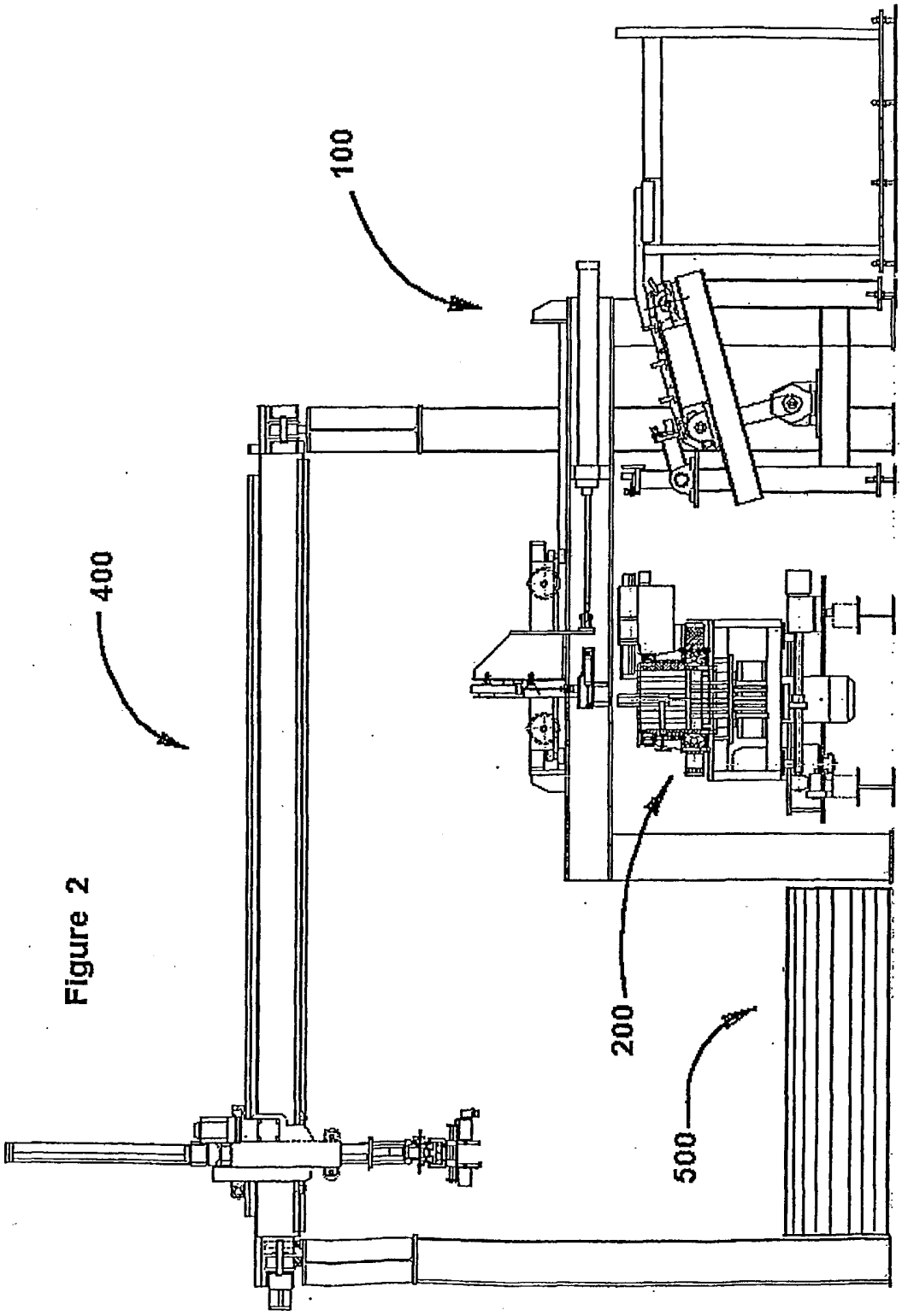

Figure 2

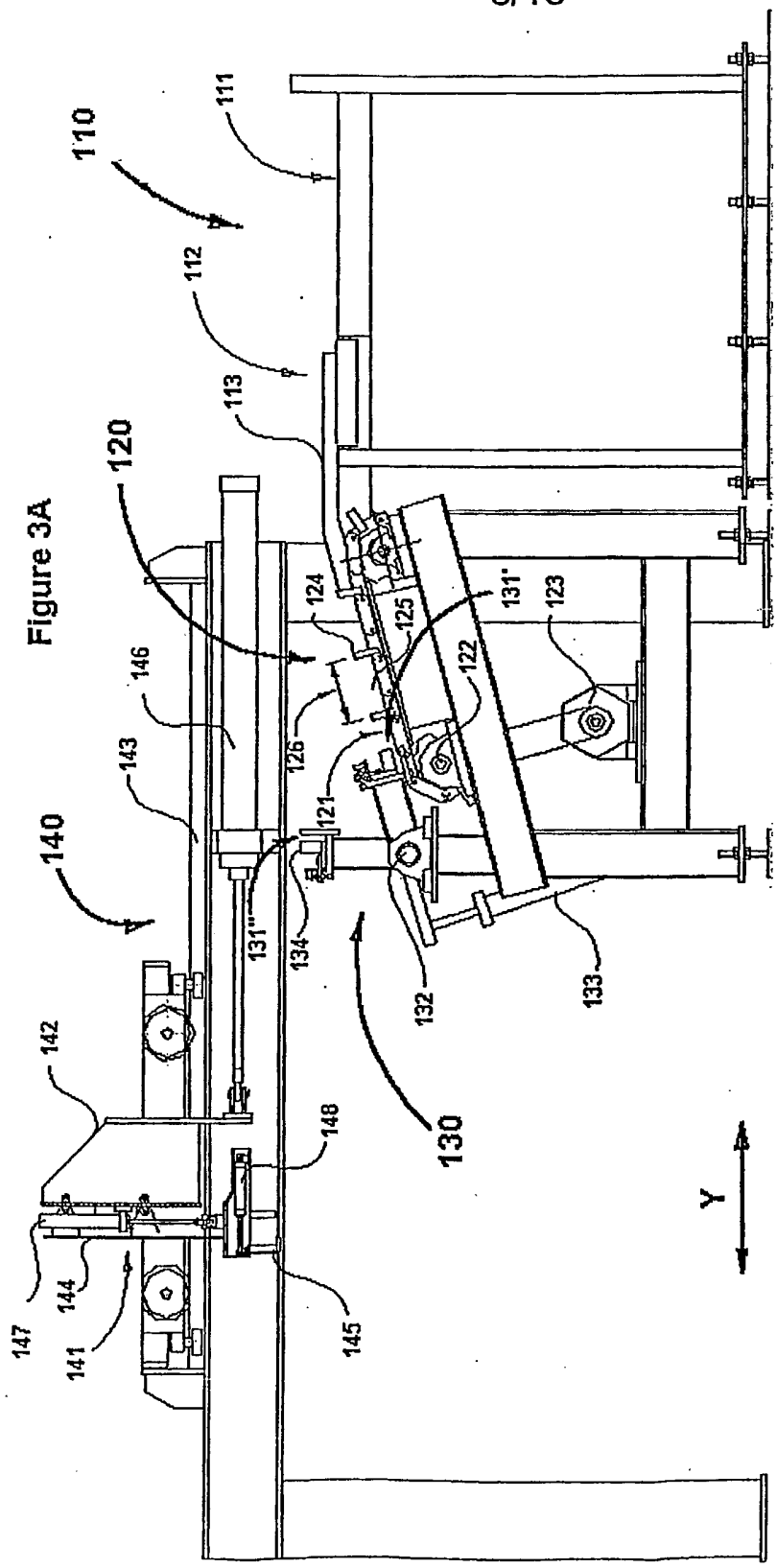
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Figure 3A

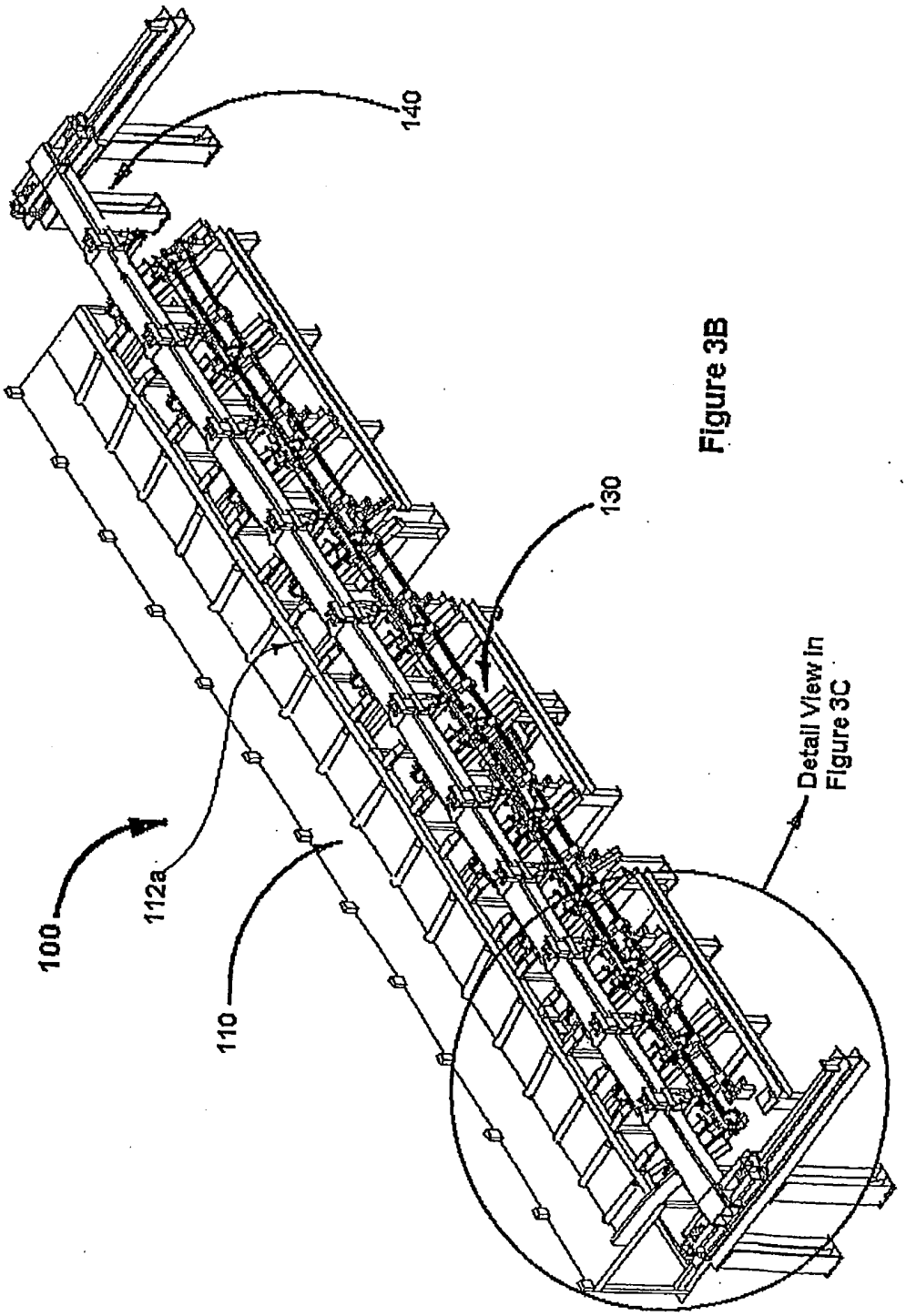

Figure 3B

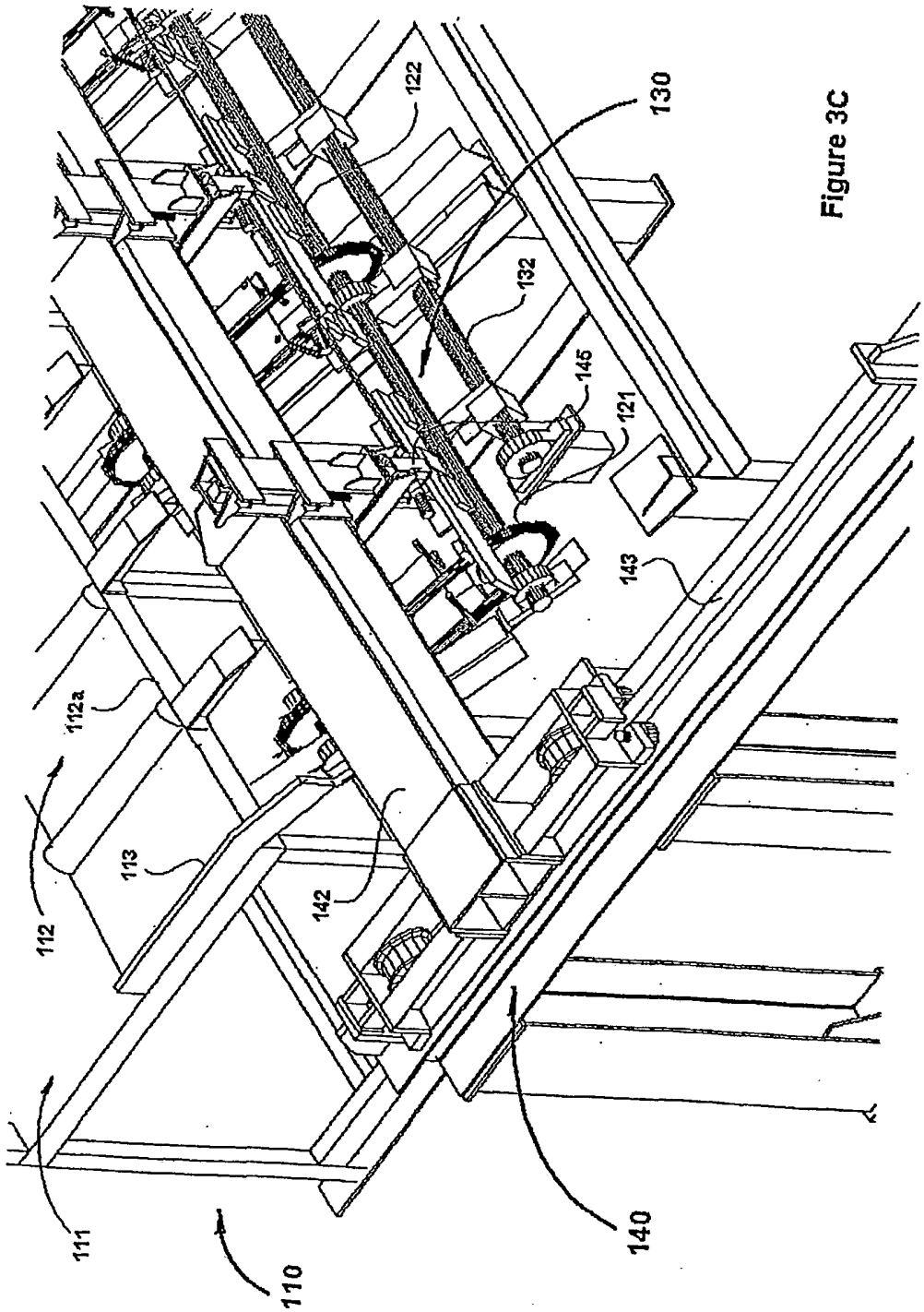

Figure 3C

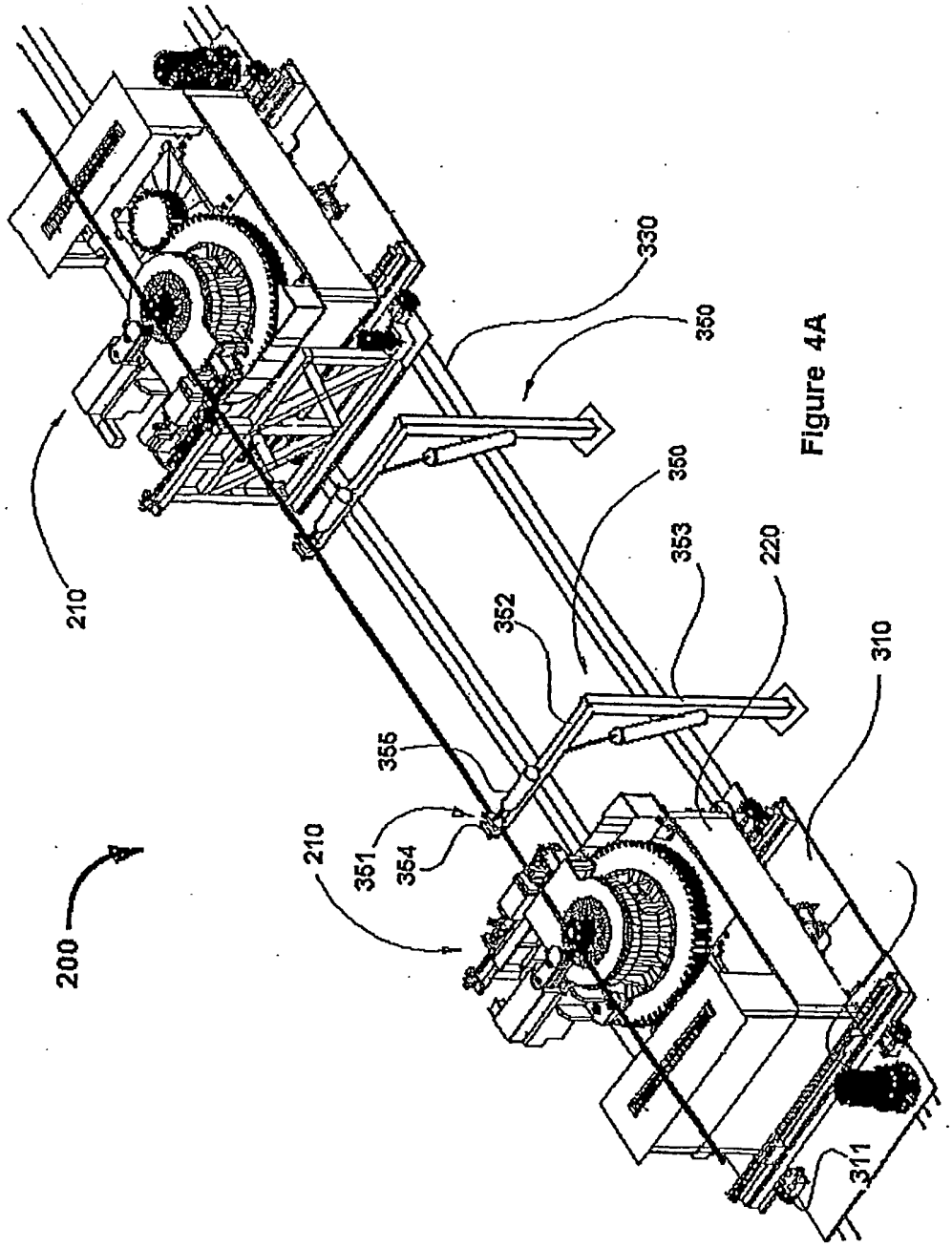

Figure 4A

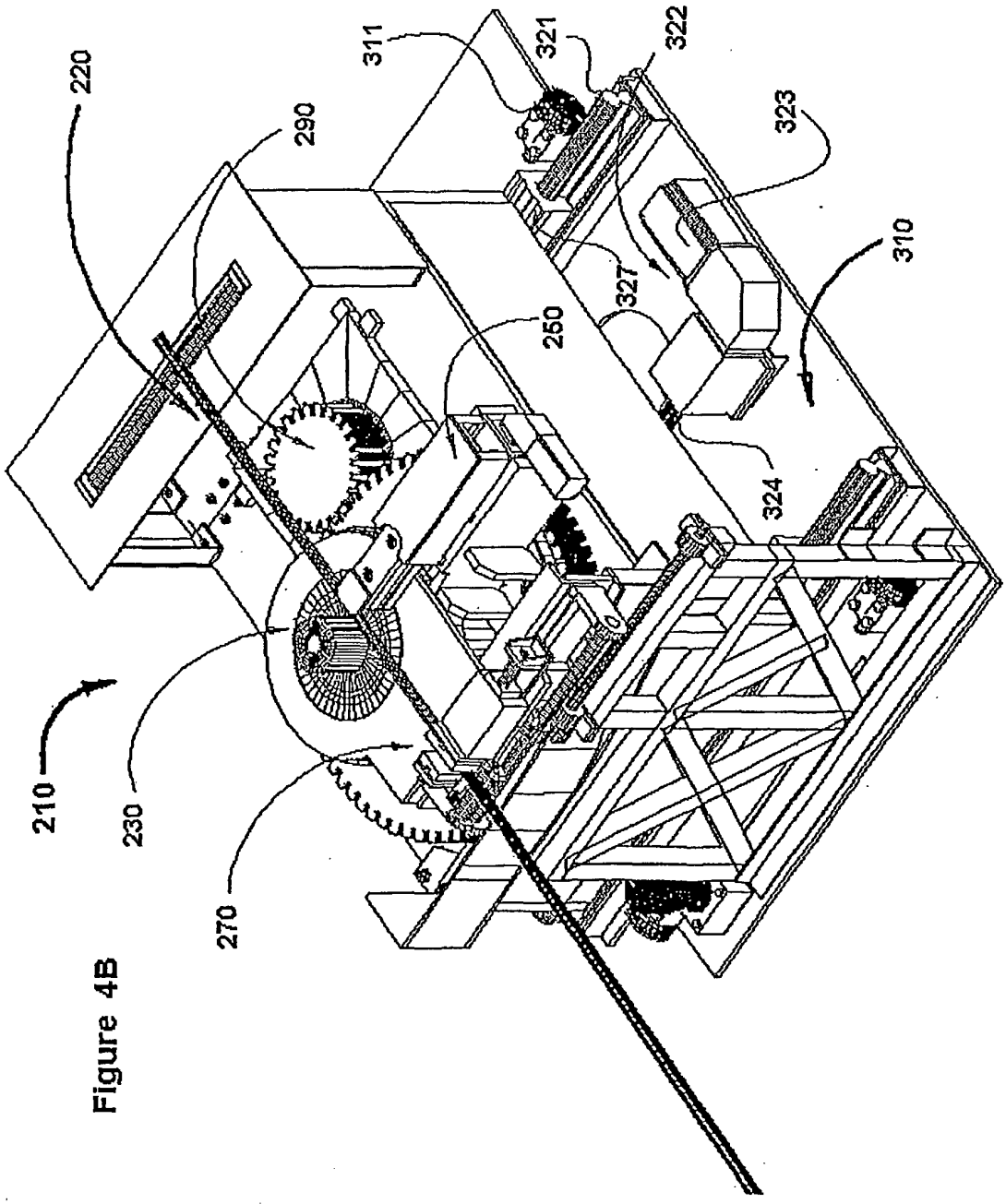

Figure 4B

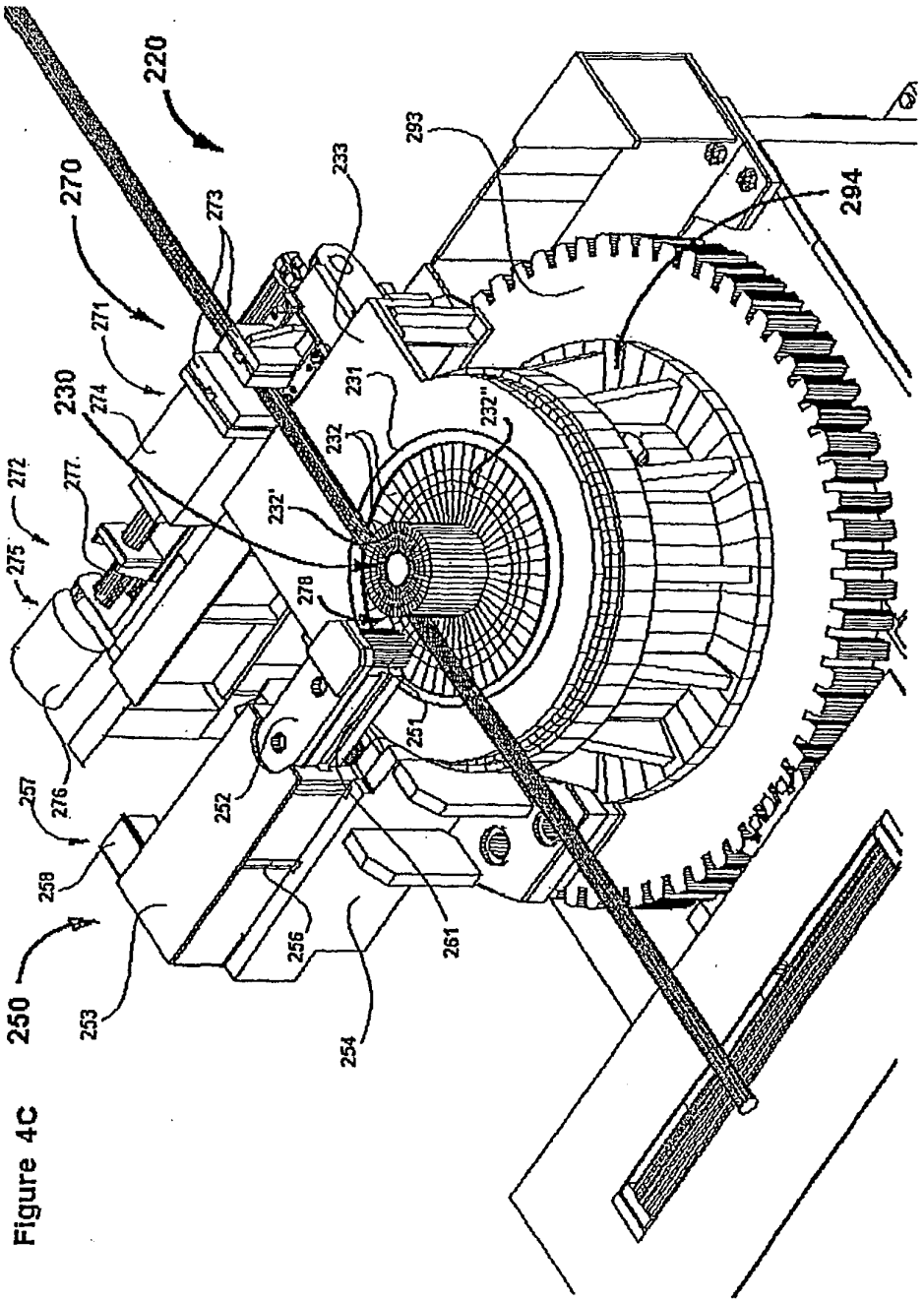
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Figure 4C

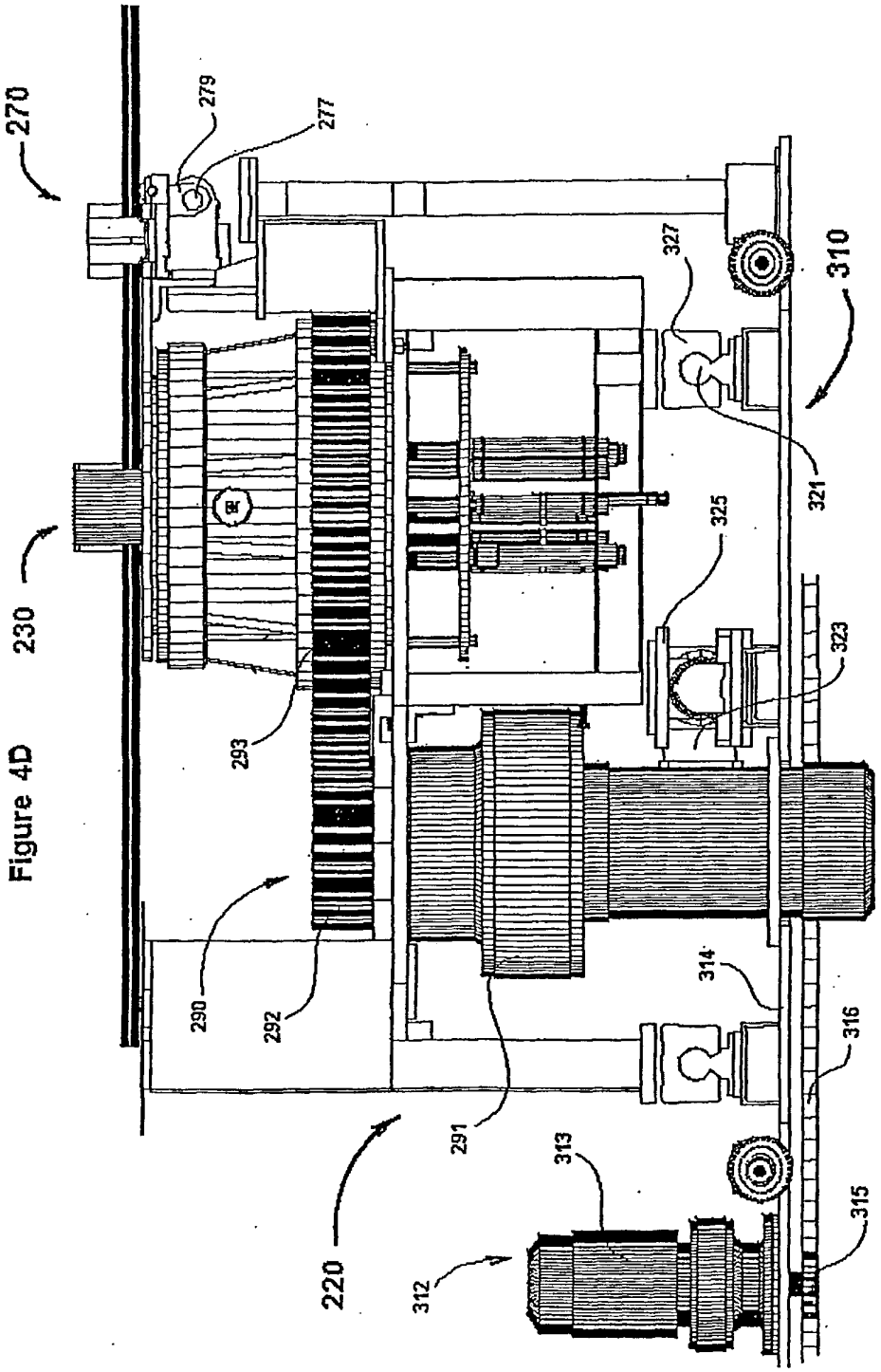
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Figure 4D

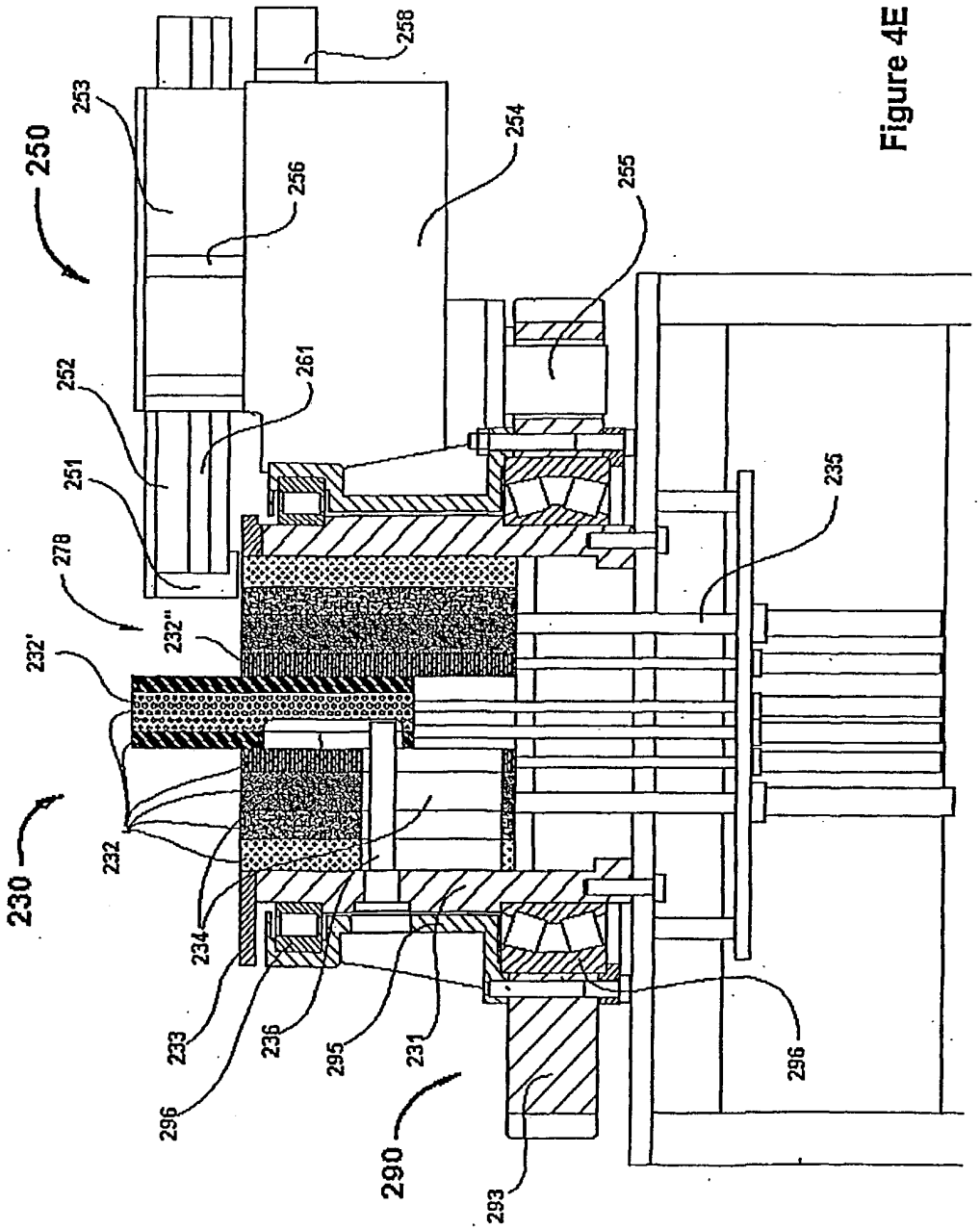
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Figure 4E

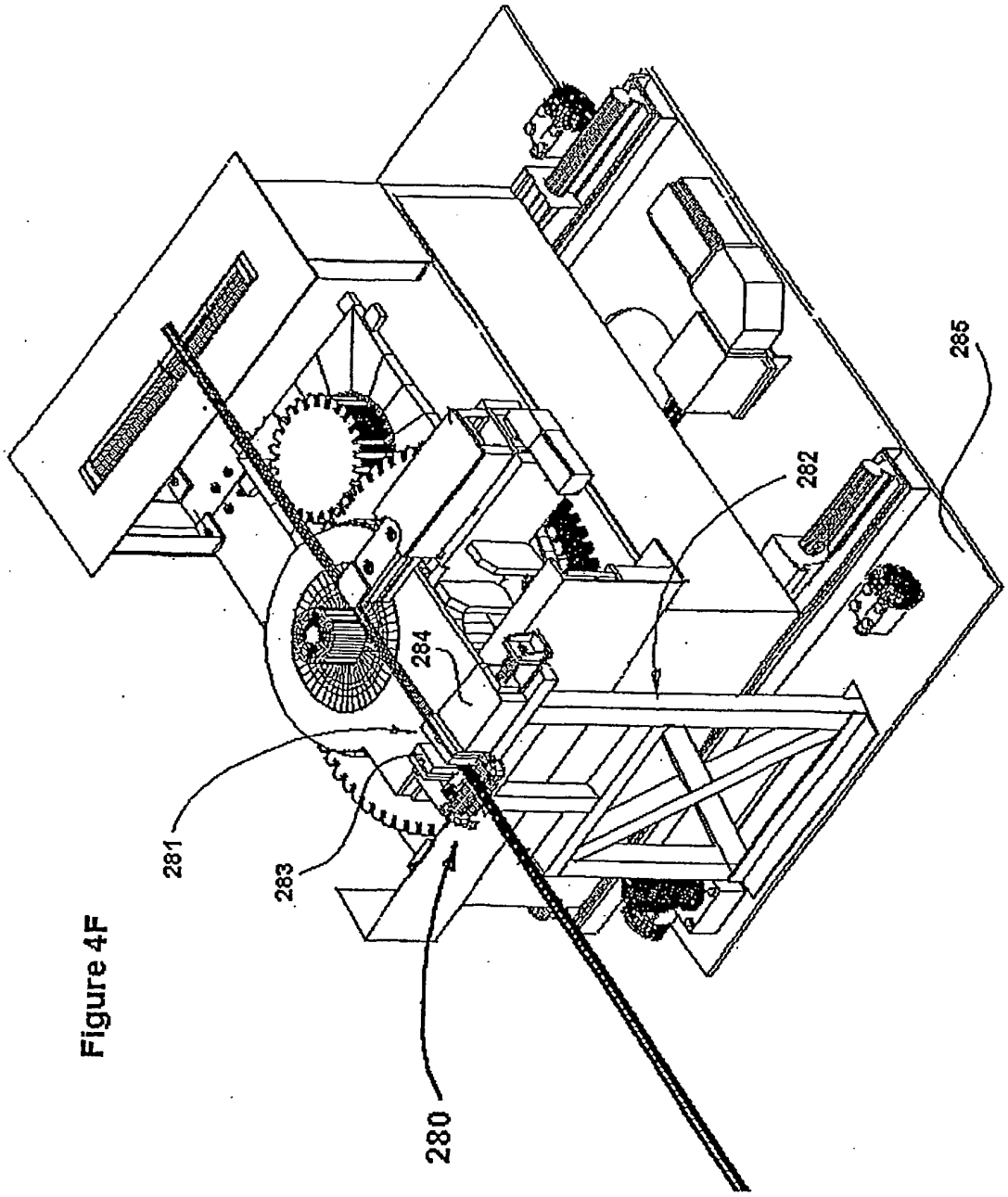

Figure 4F

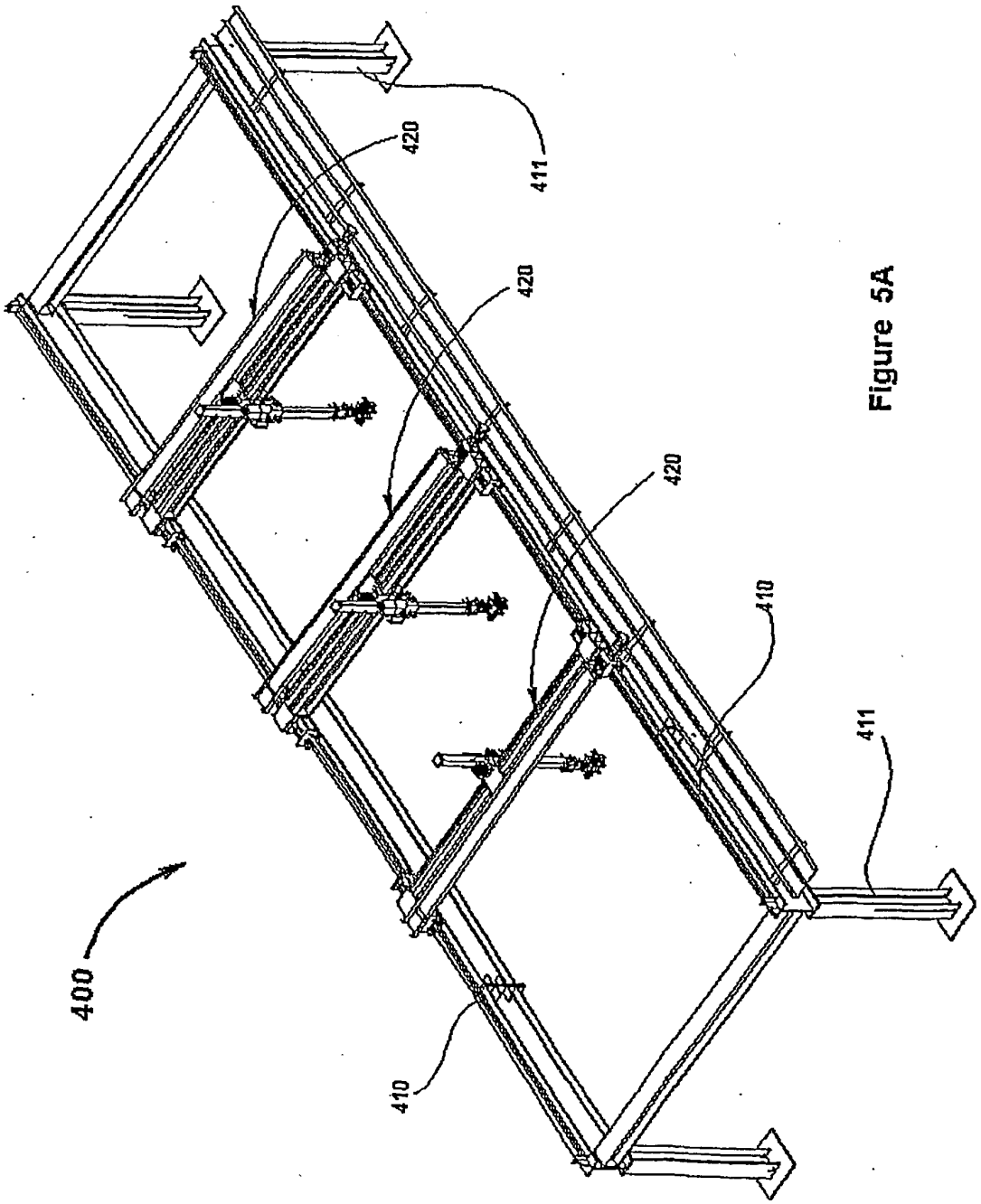

Figure 5A

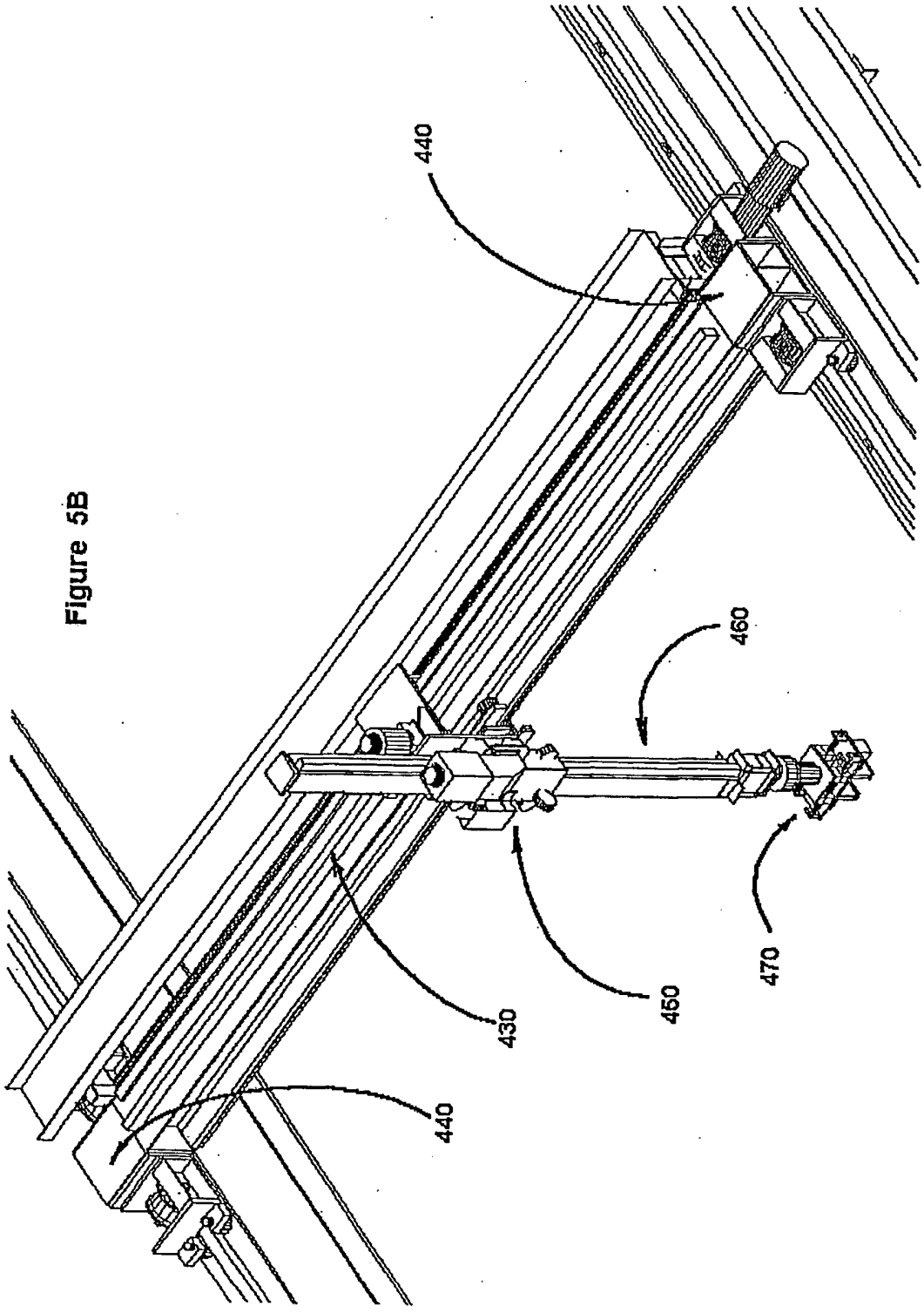

Figure 5B

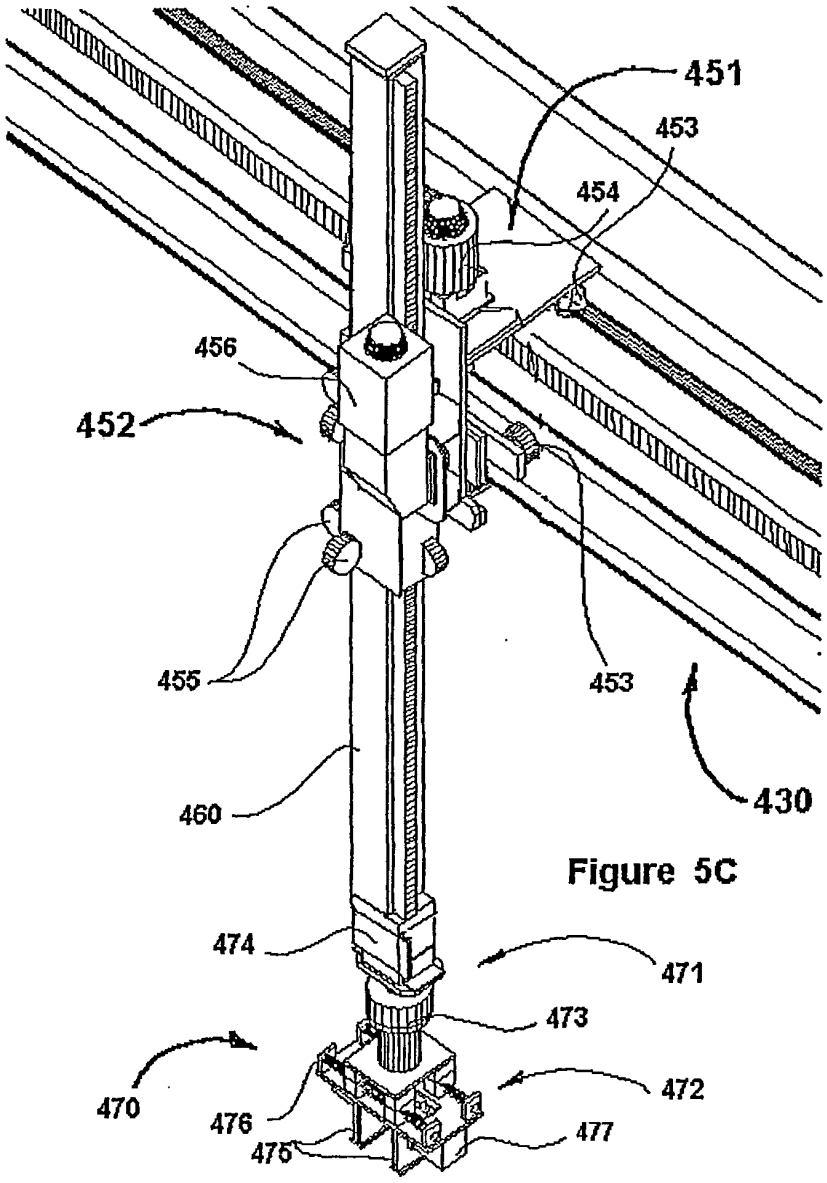
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Figure 5C

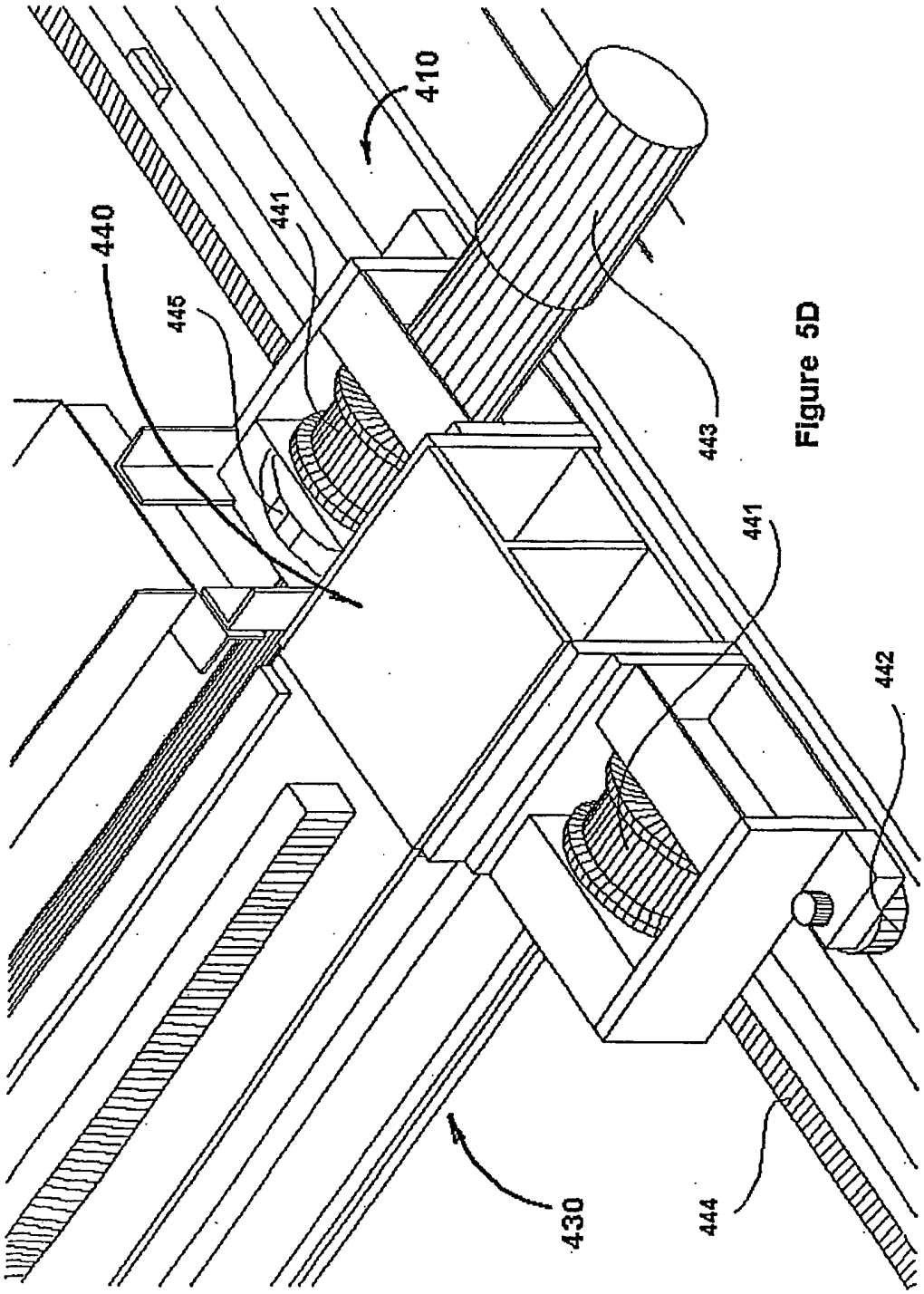

Figure 5D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG01/00108

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: B21D 7/02, 37/00, 43/00, 43/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D 7/-, 43/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPAT: IPC as above and feed, transfer or convey, unload, ring, bar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 432468 A (PEDDINGHAUS) 19 June 1991 Whole Document	1, 3, 7, 12
X	EP 501212 B (DEL FABRIO) 2 September 1992 Whole Document	1, 3, 7, 12
X	EP 648577 B (PERUZZI) 19 October 1993 Whole Document	1, 3, 7, 12

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 July 2001	18 July 2001
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **D.G. FRY** Telephone No : (02) 6283 2130

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG01/00108

C (Continuation). **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5357778 A (TSAI) 25 October 1994 Whole Document	1, 3, 7, 12
A	US 5182932 A (RITTER ET AL) 2 February 1993 Whole Document	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG01/00108

Box I **Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos :

because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos :

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos :

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II **Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1 - 8 and 12 relate to an automated bar bending system, which includes feeding, bending and unloading systems.
Claims 9 and 10 relate to first and second groups of former rings to enable bars to be bent to different radii.

These claims have no common technical features and are thus considered to be different inventions.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SG01/00108

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	432468	DE	3941291				
EP	501212	CA	2061221	IT	1248136	JP	5069070
		US	5228322	IT	1253000		
EP	648577	IT	1260998				
US	5357778	NONE					
US	5182932	AT	2206/89	AU	60555/90	CA	2042021
		DD	297084	EP	419441	PT	95366
		WO	9104113	AT	279/90		

END OF ANNEX